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Maternal dental history and child's birth outcome and early cognitive development

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Summary

Prenatal exposure to high levels of mercury, radiation, and inflammation have been associated with adverse reproductive outcomes such as increases in preterm delivery, low birthweight, and delayed neurodevelopment. Few data are available to evaluate the potential effects of prenatal low-level exposure to these factors as might occur during dental care. We evaluated maternal dental history prior to and during pregnancy in relation to birth outcomes and early communicative development among offspring in a large cohort (n=7375) of British children born in 1991–1992. Dental history was assessed by questionnaire. The child's communicative development was assessed using the MacArthur Communicative Development Inventory at 15 months of age. Total mercury was measured in umbilical cord tissue for a subset of the children. Overall, dental care, including amalgam fillings, was not associated with birth outcomes or language development. Having x-rays taken during pregnancy was not associated with birthweight measured continuously (β=14.7, p=0.4), but was associated with slightly increased odds of having a term, low birthweight baby (OR 1.9, 95%CI 1.0–3.4). More detailed evaluation of the potential adverse effects of elective dental treatment during pregnancy, particularly dental x-rays, may be warranted.

Introduction

During pregnancy, there is a tendency for periodontal disease to develop or worsen, possibly as a result of hormone fluctuation.[1–7] The American Dental Association promotes that, "Maintaining good oral health during pregnancy can be critical to the overall health of both expectant mothers and their babies.…pregnant women should continue to see a dentist regularly for oral exams and professional teeth cleanings."[8] Although dental treatment during pregnancy may benefit a woman's oral health, little research has been conducted on whether common dental procedures convey risk to the developing fetus. A routine dental visit could include x-rays (exposure to small doses of radiation), dental scaling and polishing (exposure to bacteria), or amalgam fillings (exposure to mercury vapor). In high doses, exposure to radiation or mercury can cause fetal death or insult the developing nervous

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system and lead to delays in the infant's growth or neurodevelopment [9–14]; however, at the lower doses suspected to occur during routine dental care, the effects of such exposures are largely unknown.

In the United States, only 34% of pregnant women receive professional dental care; those who do are more likely to have dental insurance and higher socioeconomic status.[15] In the United Kingdom, most pregnant women receive dental care, which is provided free during pregnancy and for the first year post partum. We have investigated the association between professional dental care during pregnancy and the child's gestational age, birthweight, and early communication development in a cohort of pregnant women and their offspring who participated in the Avon Longitudinal Study of Parents and Children (ALSPAC).

Methods

Study population

All pregnancies of mothers resident in Bristol, England and surrounding areas with expected dates of delivery between April 1991 and December 1992 were eligible for the ALSPAC study.[16,17] Expectant mothers were recruited during routine prenatal health visits. An estimated 85% of the eligible population participated (approximately 15,000 pregnancies). The present investigation was restricted to singleton live born children with data on gestational age and birthweight, and whose mothers provided prenatal dental history (n=8251). The ALSPAC Ethics and Law Committee established ethical standards for human subject which were approved by the institute's review committee. Mothers provided consent for participation and analysis of biological samples.

Data Collection

Exposure Measures—Mothers provided their dental history by completing a mailed questionnaire at 33 months postpartum. Each mother reported how many silver (amalgam) fillings were in her mouth at the time she became pregnant (0, 1, 2–3, 4 or more), whether she went to the dentist at all during pregnancy (yes/no), and if so, whether she received dental x-rays (yes/no) or silver (amalgam) fillings placed (yes/no) or removed (yes/no).

Total mercury concentration was analyzed in umbilical cord tissue taken at birth from a convenience sample of children, as study funds allowed. Samples were stored at −20°C and analyzed using cold vapor fluorescence spectrometry at Sheffield Hallam University using reference samples and standard laboratory practices to ensure validity and reliability. Prior to analyses, 1 cm cord tissue samples were washed with distilled water to remove cord blood, weighed, and digested by closed system microwave digestion using nitric acid and hydrogen peroxide. Mercury concentrations were expressed as μg/g of cord (wet weight). One thousand forty participants had the umbilical cord mercury and covariate data needed for this analysis.

Outcome Measures—Gestational age and birthweight were ascertained from hospital records. Gestational age was determined by using the last menstrual period to date the onset of pregnancy. However, if this differed by 2 weeks or more from the clinical assessments (particularly early ultrasound) records were reviewed and a revised estimate (in weeks) given. Infants were classified as preterm if they were born prior to 37 completed weeks gestation (regardless of birthweight). Infants were classified as term low birthweight if they were born on or after 37 completed weeks gestation and weighed less than 2500grams at birth. Dividing low birthweight infants into term and preterm groups is useful because it separates babies who are small because of gestational age from those who are small because of intrauterine growth retardation.

The ALSPAC adaptation of the MacArthur-Bates Communicative Development Inventory (MCDI) was used to assess the child's vocabulary comprehension and social communication at 15 months of age. The MCDI is a parent-completed assessment of the child's language development and general communication that is designed for use in clinical research.[18, 19] Children were excluded from analysis of their developmental assessment if the MCDI was completed more than 4 months after the target assessment date (15 months).

Covariates—Information about other factors that could affect the relationship between dental history and birth outcomes and neurodevelopment was obtained from mailed questionnaires completed by the mother during pregnancy, shortly after delivery, and in the years following their children's birth. These included descriptions of the mothers diet, health, demographics, and lifestyle factors. Fish intake and breastfeeding practices were also included to adjust for other sources of mercury and nutrients. Mothers reported their own fish intake by questionnaire completed at 32 weeks gestation. They reported their child's fish intake and breastfeeding practices by questionnaires completed 6 and 15 months after the child's birth.

Data Analysis

The change in birthweight, gestational age, and communicative development score with exposure to each component of dental care was estimated by linear regression. The odds ratio (OR) and 95% confidence intervals (CI) for exposure to each component of dental care relative to low birthweight and preterm birth status were estimated using logistic regression. For each communicative development score, a dichotomous variable was created to indicate a low score (the lowest tenth percentile of the age-adjusted z-score). Logistic regression was used to estimate the OR and 95% CI for maternal dental history relative to low communicative development scores. The geometric mean mercury level in umbilical cord was estimated according to dental care history for the sample with necessary data.

Analyses for birth outcomes were adjusted for the child's sex, birth order (first born /non-first born), and maternal age (years), fish consumption (rarely or never, once per 2 weeks, 1–3 times per week, and 4 or more times per week), prenatal smoking (yes/no), prenatal alcohol use (yes/no), and level of educational achievement according to the English system (CSE=low, Vocational=moderately low, O level=moderate, A level=moderately high, Degree=high, and missing). The analysis of birthweight was also adjusted for gestational age. The association between dental care and language development was further adjusted for the child's age at testing (weeks), breastfeeding (yes/no), weekly fish consumption at age 12 months (yes/no), and the quality of the parent and home environment, represented by a self-completion adaptation by ALSPAC of the Home Observation for Measurement of the Environment (HOME) score (continuous).[20]

Results

Among those eligible for participation, 7375 had complete data on the exposures, outcomes and covariates included in these analyses. The mothers included in the present analysis were slightly older than other ASLPAC subjects (mean age 29 versus 27 years), more likely to have had dental care during pregnancy (89 versus 84%), to have a university degree (15% versus 7%) and to have breastfed their child (68% versus 56%), and less likely to have smoked during pregnancy (16% versus 26%) (Table 1). The characteristics of the children with umbilical cord samples for analysis were essentially the same as those without such samples (data not shown).

Nearly 90% of the women in this study received dental care during pregnancy (Table 1). Among those, 31% had amalgams placed or removed. Nearly all women who had an

amalgam removed also had one placed (>99%). Most women (71%) also had 4 or more amalgams in place prior to conception. Women who received dental care during pregnancy were more likely to have more amalgams in place at the time of conception, more education, eaten more fish, and to have been non-smokers compared to those who did not.

Dental care was not associated with gestational age (in weeks) or birthweight (in grams) (Table 2); although, birthweight modestly increased with the number of amalgams in place at the time before conception (β=22.9 grams per increase in amalgam category, p=0.0001). Results were similar when models were run separately for term and preterm births (data not shown). The odds of term low birthweight or preterm birth were not associated with maternal history of any dental care during pregnancy or having an amalgam filling placed or removed. However, receiving dental x-rays during pregnancy was associated with a higher probability of term low birthweight (OR 1.9, 95%CI 1.0–3.4). Conversely, women who had more amalgams in place at conception had lower probability of having a term low birthweight infant (p=0.02). When restricted to mothers who received dental care during pregnancy, results associated with each type of dental procedure were unchanged (data not shown).

Early MCDI communicative development scores were not associated with receiving any dental care, or with specific procedures such as amalgam fillings or x-rays (Table 3). Similarly, the odds of scoring low (in the lowest 10^{th} percentile of age adjusted z-scores) on the assessments were generally not associated with maternal dental history, although the odds of a low social activity score were slightly reduced among children whose mothers had dental amalgams in place at the time of conception. These relationships were not modified by infant's term/preterm status, nor did they change when adjusted for gestational age and birthweight (data not shown). When analyses were restricted to only women who had some dental care, exposure to specific dental procedures were not associated with the children's early communicative development (data not shown).

Although the mean umbilical cord mercury concentration was slightly higher among those whose mothers had any dental care (p=0.07), it did not differ markedly in relation to amalgam fillings during pregnancy (p=0.34) or by the number of amalgams in place prior to conception (p=0.32) (Figure 1). Overall, the total mercury levels in umbilical cord tissue were low for this population (median=0.01 μg/g wet weight) and not associated with gestational age (β=0.03, p=0.63), birthweight (β=−18.6, p=0.22) or developmental scores (reported elsewhere).[21] The relation between maternal dental history and child's communicative development was unchanged when adjusted for mercury level among the subset of children with umbilical cord mercury data.

Discussion

Gestational age and birthweight were not associated with general dental care during pregnancy or the placement of removal of amalgam fillings in these data. However, the number of amalgams in place prior to conception was associated with higher birthweight overall, while having dental x-rays taken during pregnancy was associated with low birthweight among infants born at term (37 or more completed weeks gestation).

Research investigating the reproductive effects of low dose radiation is limited. Our results are consistent with other recent reports of an association between dental radiation and decreased birthweight.[22,23] Hujoel, et al. reported x-rays to be more strongly associated with term low birthweight than with low birthweight generally; but did not separately report the results for preterm births, which would have represented the majority of the low birthweight. [22] Low birthweight among term infants may reflect intra-uterine growth

retardation, while among preterm infants; it often reflects the early delivery. Our study found no association between x-rays and preterm birth. The Hujoel, et al study[22] was criticized for lack of adjustment for key covariates and for crude quantification of radiation dose based on the number of x-rays – which lead to the conclusion that a stronger association existed with higher radiation, especially in the first trimester.[24–27] While it is possible that dental radiation could affect fetal growth, the ability to evaluate a causal association in our data was limited. Very few women in our study reported having dental x-rays more than once and the number of x-rays taken during that session was not recorded, thus we were unable to assess even a crude dose-response relationship between radiation and birthweight. In addition, the indication for x-rays was not known. The association observed could result from the underlying indication for x-rays rather than radiation. Other studies that have investigated reproductive effects of radiation were focused on radiation for cancer treatment or industrial accidents,[14, 28–32] which differ from dental radiation by exposure level and target site.

Exposure to high doses of mercury, specifically methylmercury from industrial accidents or contamination of food, has been associated with adverse birth outcomes and neurodevelopment.[11, 32–37] The effects of occupational exposure to mercury vapor on reproductive and developmental outcomes have been evaluated but remain ambiguous.[38–42] Mercury exposure from receiving dental treatment is generally low, even though dental amalgams are the most common source of human exposure to inorganic mercury in the general population.[11, 12, 43–45] Studies have reported blood mercury levels to be higher among individuals with amalgam fillings,[12, 46, 47] although we did not find this trend in our the umbilical cord tissue data. Maternal and fetal mercury levels also tend to be correlated. Mercury crosses the placenta and accumulates in the fetus.[45, 48–51] Yet, few data exist that suggest an adverse effect of mercury from maternal dental amalgams with respect to birth outcomes or development.[45] One recent case-control study reported no association with low birthweight.[52] We found no association with prenatal placement/removal of amalgams in these data; although the existence of amalgams prior to pregnancy was associated with reduced odds of term low birthweight, possibly due to residual confounding by socioeconomic status.

We also found no association (beneficial or adverse) between maternal general dental care during pregnancy and gestational age, birthweight, or neurodevelopment, which supports other recent reports.[53] Periodontal infection may develop or become more severe during pregnancy.[1, 2, 4] While this deserves further investigation, our study did not have documentation of the woman's periodontal health during pregnancy or whether her dental care included treatment for periodontal infection. Receiving any professional dental care during pregnancy, however, was not associated with birth outcome.

Maternal dental history was also not associated with communicative development among the children in this study. The developmental scores, measured by the MacArthur-Bates Communicative Development Inventory, changed only fractions of a point among children born to women who had any professional dental care, x-rays or amalgam fillings during pregnancy. The relationship between the number of amalgams before conception and reduced odds of low communication scores may reflect residual confounding by social class even though analyses were adjusted for maternal education and the HOME score. The more educated mothers tended to have more amalgams in their mouths before pregnancy and their children tended to have better communication scores. These data do not suggest that dental treatment during pregnancy conveys great risk or benefit to the infant's language development at 15 months; although lack of an association between dental exposures and neurodevelopment can not be ruled out based on a single assessment of young children in this study. The communicative developmental assessment was completed by the mother's

report of her child's language and communication skills. Other developmental domains, such as motor development and behavior, may be more sensitive to the exposures related to dental care and less reliant on maternal report. In addition, subtle variation in development is sometimes not detectable until children are older.[54]

This study collected very basic information about dental procedures that we used as a proxy for fetal exposure to factors such as mercury and radiation. Total mercury levels measured in this population were low and likely reflected both organic mercury taken in through diet and inorganic mercury from dental amalgams. There was limited variability among our measure of the number of amalgams in place prior to conception, which limited our ability to detect associations. No biologic marker or specific record of radiation dose was available. The information on dental care was self-reported 33 months postpartum, thus subject to recall error that was probably non-differential with respect to the child's development, which would bias these results toward the null. Details were unavailable regarding the number and timing of specific procedures during the pregnancy, the use of precautions such as lead aprons during x-rays or the mother's oral health prior to pregnancy. Collecting more detail about the nature, frequency, and timing of dental care during pregnancy may have improved our ability to detect beneficial or adverse effects from professional dental care during pregnancy.

Participants in the ALSPAC study are generally representative of the women and children resident in Avon during the early 1990s;[17] although those with the complete data needed for these analyses appeared to be more educated and had slightly better health behavior indicators. Because dental care is free for all women, we expect the typical effect of socioeconomic factors to be minimal and accounted for in the analysis. However, the inverse association between the number of amalgams in place before conception and birthweight suggests potential influence of unmeasured confounding.

Despite the limited details in these dental data, we were able to conduct a general evaluation of the potential associations with reproductive outcomes and for the first time, early communicative development, in a very large British population. The results of this study do not indicate that a strong relationship exists between maternal dental care and children's gestational age, birthweight or communicative development. However, the elevated risk of low birthweight associated with receiving dental x-rays during pregnancy warrants a more detailed evaluation. Future investigations should improve exposure assessment, with detailed information on the timing and type of dental treatment during gestation, biologic measures of mercury exposure, protective measures taken during radiation, and consideration of overall oral health status. Such improvements should help to further our understanding of the potential effects of prenatal dental care on infant health.

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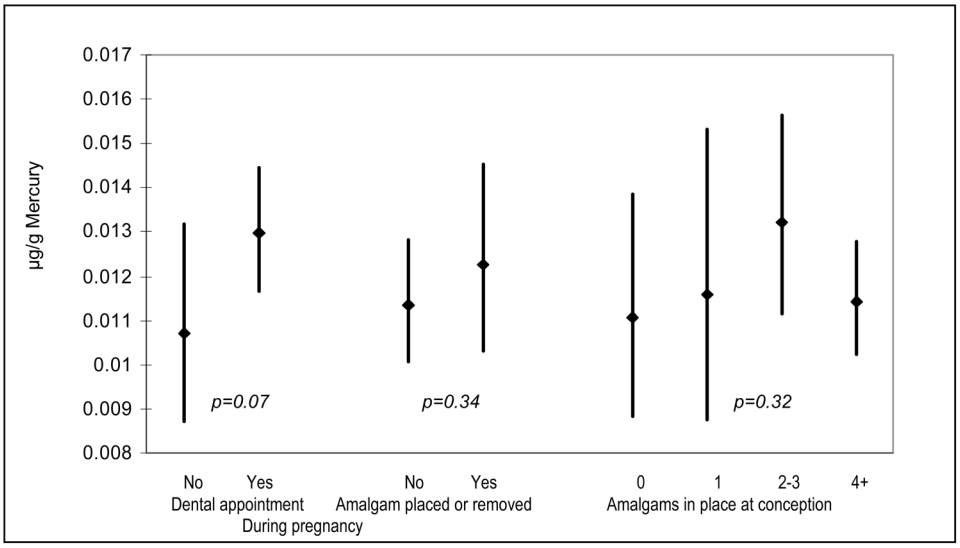

Figure 1.

Geometric mean mercury levels of total mercury in umbilical cord samples and 95% confidence limits by maternal dental history (n=1040)

*Adjusted for maternal age, education, parity, use of alcohol or tobacco, fish intake, HOME score, and child's sex and gestational age. P-value is for test of difference between group means.

Table 1

Characteristics of mothers and children in the ALSPAC Study

	Included in analysis		Not Included in analysis	
	n=7375	%	n=7536[c]	%[d]
Maternal Characteristics				
Dental care during pregnancy				
No	786	10.7	386	16.0
Yes	6589	89.3	2091	84.0
Missing			5049	
Xray during pregnancy				
No	6807	92.3	2285	91.9
Yes	568	7.7	199	8.1
Missing			5052	
Amalgam placed or removed during pregnancy				
No	5354	72.6	1805	72.5
Yes	2021	27.4	682	27.5
Missing			5049	
Amalgams in place before pregnancy				
0	531	7.2	197	11.1
1	383	5.2	15	8.5
2–3	1196	16.2	349	19.5
4+	5265	71.4	1104	60.9
Missing				
Ate fish during pregnancy				
None	907	12.3	859	16.7
1 per 2 weeks	1336	18.1	1117	21.7
1–3 per week	2270	30.8	1548	30.1
4+ per week	2862	38.8	1615	31.5
Missing			2397	
Age	7375	28.9 (4.6)[a]	6973	26.9 (5.1)[a]
Education				
CSE (very low)	763	10.4	1029	13.7
Vocational (low)	647	8.8	617	8.2
O Level (moderate)	2640	35.7	1797	23.8
A Level (moderately high)	1912	25.9	969	12.9
Degree (high)	1129	15.3	496	6.6
Missing	284	3.9	2628	34.9
Smoke during pregnancy				
No	6220	84.3	3815	73.7
Yes	1155	15.7	1359	26.3
Missing			2362	
Alcohol during pregnancy				

	Included in analysis		Not Included in analysis	
	n=7375	%	n=7536[c]	%[d]
No	3290	44.6	2822	46.5
Yes	4085	55.4	3248	53.5
Missing			1466	
Child Characteristics				
Birth Outcome				
Term Normal Birthweight	6950	94.2	6216	91.5
Term Low Birthweight	108	1.5	151	2.2
Preterm	317	4.3	427	6.3
Missing			742	
Gestational Age (weeks)	7375	39.6 (1.7)[a]	7003	39.2 (2.5)[a]
Birthweight (grams)	7375	3450 (521)[a]	6801	3331 (593)[a]
Child's sex				
Female	3815	51.7	3619	51.5
Male	3560	48.3	3413	48.5
Missing				
Birth order				
First born	4001	45.8	3428	42.9
Not first born	3374	54.2	2581	57.1
Missing			1527	
Total Mercury (n=1040)		0.013 (1.03)[b]		
MCDI crude score				
Vocabulary comprehension	6780	72.1(31.6)[a]	3136	70.2 (33.6)[a]
Social activity	7120	17.4 (5.6)[a]	4022	17.6 (5.9)[a]
Ever breastfed				
No	2305	32.4	1721	44.2
Yes	4776	67.6	2207	55.8
Missing			3608	
Child ate fish at 12 months				
No	1338	18.8	1137	28.3
Yes	5811	81.2	2908	71.7
Missing			3491	

[a]Mean (Standard Deviation)

[b]Geometric Mean (Standard Error)

[c]The n for each variable differs based on the number missing data values for that variable.

[d]The % among non-missing data for that variable.

Table 2

Association between dental care prior to and during pregnancy and birth outcome.

Term Normal Birthweight[a]			Term Low Birthweight				Preterm				Birthweight Change in grams			Gestational Age Change in weeks		
	n=6950	%	n=108	%	OR[b]	95%CI	n=317	%	OR[b]	95%CI	β[bc]	SE	p	β[b]	SE	p
During Pregnancy																
Dental care																
No	727	*90*	14	*13*	**1.0**		45	*14*	**1.0**							
Yes	6223	*11*	94	*87*	**1.0**	0.5, 1.8	272	*86*	**0.8**	0.5, 1.1	**−25.5**	17	*0.1*	**0.01**	0.1	*0.9*
Xrays																
No	6422	*8*	94	*13*	**1.0**		291	*92*	**1.0**							
Yes	528	*92*	14	*87*	**1.9**	1.0,3.4	26	*8*	**1.2**	0.8,1.8	**14.7**	19	*0.4*	**0.01**	0.1	*0.9*
Amalgam placed or removed											**−0.8**	12	*0.9*	**0.04**	0.05	*0.4*
No	5032	*72*	80	*74*	**1.0**		242	*76*	**1.0**							
Yes	1918	*28*	28	*26*	**0.9**	0.6, 1.4	75	*24*	**0.9**	0.6,1.1						
Before Pregnancy																
Amalgams in place: 0	483	*7*	17	*16*	**1.0**		31	*10*	**1.0**							
1	362	*5*	6	*6*	**0.5**	0.2, 1.4	15	*5*	**0.7**	0.3,1.2						
2 or 3	1133	*16*	14	*13*	**0.4**	0.2, 0.7	49	*16*	**0.7**	0.5,1.2						
4+	4972	*72*	71	*66*	**0.4**	0.2, 0.8	222	*70*	**0.8**	0.6,1.3						
Trend						*p=0.02*				*p= 0.3*	**22.9**	6	*0.0001*	**0.02**	0.02	*0.4*

[a]-Reference for logistic regression models

[b]-Odds Ratios (OR) and regression coefficients (β) are adjusted for child's sex, birth order, maternal fish consumption, age, education, other dental history variables, prenatal smoking and alcohol use.

[c]-Regression of birthweight is additionally adjusted for gestational age (weeks)

Table 3

Association between Maternal Dental Care & Child's MacArthur Communicative Development Inventory Scores at 15 months of age.

Reference			Vocabulary Comprehension Low 10th percentile				Change in score			Reference		Social Activity Low 10th percentile				Change in score		
	n=6033	%	n=672	%	OR	95%CI	β	SE	*p*	n=6708	%	n=589	%	OR	95%CI	β	SE	*p*
During Pregnancy																		
Dental care																		
No	625	*10*	70	*10*	**1.0**					608	*10*	88	*13*					
Yes	5408	*90*	602	*90*	**1.0**	0.8,1.4	**−0.5**	1.2	*0.7*	5440	*90*	572	*87*	**0.8**	0.6,1.1	**−0.1**	0.2	*0.8*
Xrays																		
No	464	*92*	59	*91*	**1.0**					*465*	*92*	604	*92*					
Yes	5569	*8*	613	*9*	**1.1**	0.8,1.5	**−1.3**	1.4	*0.4*	5583	*8*	56	*9*	**1.1**	0.8,1.5	**−0.2**	0.2	*0.5*
Amalgam placed or removed																		
No	4370	*72*	497	*74*	**1.0**					*4380*	*72*	489	*74*					
Yes	1663	*28*	175	*26*	**0.9**	0.8,1.1	**0.6**	0.9	*0.5*	1668	*28*	171	*26*	**1.0**	0.8,1.2	**0.3**	0.1	*0.03*
Before Pregnancy																		
Amalgams in place: 0	422	*7*	52	*8*	**1.0**					*405*	*7*	10	*10*	**1.0**				
1	296	*5*	40	*6*	**1.1**	0.7,1.7				*303*	*5*	5	*5*	**0.6**	0.3,0.9			
2 or 3	969	*16*	103	*15*	**1.0**	0.7,1.4				*961*	*16*	17	*17*	**0.8**	0.6,1.2			
4+	4346	*72*	477	*71*	**0.9**	0.7,1.3				*4379*	*72*	68	*68*	**0.8**	0.5,1.0			
Trend						*p=0.6*	**−0.4**	0.4	*0.4*						*p=0.3*	**−0.1**	0.1	*0.5*

Models adjusted for child's sex, birth order, breastfeeding, fish consumption at 12months of age, maternal fish consumption, dental history, age, education, prenatal smoking and alcohol use.